Amendments to the Claims

1. (Currently amended) An apparatus for producing an angiographic image representation of a subject, the apparatus comprising:

an imaging scanner that acquires imaging data from at least a portion of a subject, the imaging data including vascular contrast;

a reconstruction processor that reconstructs ~~an~~ a three-dimensional image representation from the imaging data, the image representation formed of image elements and exhibiting vascular contrast; and

a processor that converts the image representation into an edge-enhanced image representation having enhanced vascular edges and divides the edge-enhanced image representation into ~~at least one~~ a plurality of two-dimensional ~~slice~~ slices formed of pixels spanning the angiographic image representation, and for each slice:

flood-fills the vascular edges to form filled regions defined by pixels having a first value,

identifies vessel centers through iterative removal of pixels having the first value from around the edges of the filled regions, and

the vessel centers identified being representative of a three-dimensional vascular structure, the processor further segmenting, tracking, extracting, enhancing, or identifying information about the three-dimensional vascular structure ~~segments, tracks, extracts, enhances, or identifies vascular information contained in the angiographic image~~ using the identified vessel centers as operative inputs.

2. (original) The apparatus as set forth in claim 1, wherein the converting of the image representation into an edge-enhanced imaged representation includes:

conditional upon the vascular contrast including black blood vascular contrast, inverting the intensities of the image elements to generate an intensity-inverted image.

3. (original) The apparatus as set forth in claim 1, further including:

a magnetic resonance contrast agent administered to the subject to improve vascular contrast.

4. (original) The apparatus as set forth in claim **1**, wherein the imaging scanner includes at least one of a magnetic resonance imaging scanner and a computed tomography scanner.

5. (currently amended) ~~The~~ An apparatus ~~as set forth in claim 1,~~ for producing an angiographic image representation of a subject, the apparatus comprising:

an imaging scanner that acquires imaging data from at least a portion of a subject, the imaging data including vascular contrast;

a reconstruction processor that reconstructs an image representation from the imaging data, the image representation formed of image elements and exhibiting vascular contrast; a processor that converts the image representation into an edge-enhanced image representation having enhanced vascular edges and divides the edge-enhanced image representation into at least one two-dimensional slice formed of pixels, and for each slice:

flood-fills the vascular edges to form filled regions defined by pixels having a first value,

identifies vessel centers through iterative removal of pixels having the first value from around the edges of the filled regions, and

~~wherein the processor~~ tags vessel overlaps and vessel furcations identified as a plurality of vessel centers corresponding to a single filled region; and

segments, tracks, extracts, enhances, or identifies vascular information contained in the angiographic image using the identified vessel centers as operative inputs.

6. (original) The apparatus as set forth in claim **5**, wherein the processor connects the vessel centers and vessel edges associated therewith starting at the vessel furcations to form segmented vessel trees including vessel furcations.

7. (original) The apparatus as set forth in claim 1, wherein the identifying of vessel centers through iterative removal of pixels includes for each iteration:

a first erosion pass operating in a first direction across the slice using a moving window having a first shape; and

a second erosion pass operating in a second direction across the slice using a moving window having a second shape.

8. (original) A method for characterizing a vascular system in a three-dimensional angiographic image comprised of voxels, the method comprising:

extracting from the angiographic image a two-dimensional slice formed of pixels;

locating imaged vascular structures in the slice;

flood-filling the imaged vascular structures to form filled regions defined by pixels having a first value;

iteratively eroding the edges of the filled regions to identify vessel center points; and

repeating the extracting, locating, flood-filling, and eroding for a plurality of slices to generate a plurality of vessel center points that are representative of the vascular system.

9. (original) The method as set forth in claim **8** wherein the locating of imaged vascular structures includes:

prior to the extracting, enhancing the vessel edges by second order spatial differentiation of the angiographic image.

10. (original) The method as set forth in claim **8** wherein the locating of imaged vascular structures includes:

prior to the extracting, enhancing the vessel intensity contours by convolving the angiographic image with a kernel formed from a second or higher order derivative of a Gaussian function.

11. (original) The method as set forth in claim **10** wherein the convolving of the angiographic image with a kernel includes:

decomposing the kernel into sinusoidal components; and

convolving the angiographic image with the sinusoidal components of the kernel.

12. (currently amended) ~~The~~ A processor for carrying out a method ~~as set forth in claim **8** further including~~ for characterizing a vascular system in a three-dimensional angiographic image comprised of voxels, the method comprising:

extracting from the angiographic image two-dimensional slices formed of pixels;

flood-filling imaged vascular structures in the slices to form filled regions defined by pixels having a first value;

eroding the edges of the filled regions to identify a plurality of vessel center points representative of the vascular system;

selecting a first vessel center point;

finding a vessel direction corresponding to the first vessel center point based on analysis of the angiographic image in the three-dimensional neighborhood of the first vessel center point;

defining a plane of the angiographic image perpendicular to the vessel direction and containing the first vessel center point;

estimating vessel boundaries corresponding to the first vessel center point in the defined plane;

repeating the selecting, finding, defining, and estimating for the plurality of vessel center points; and

interpolating the estimated vessel boundaries to produce a vascular representation.

13. (currently amended) The ~~method~~ processor as set forth in claim **12** wherein the estimating of vessel boundaries includes:

defining an initial geometric contour arranged about the vessel center and lying in the defined plane; and

iteratively optimizing the geometric contour constrained to lie in the defined plane and constrained by at least one of a selected distance from a vessel center and another estimated vessel boundary.

14. (currently amended) The ~~method~~ processor as set forth in claim **13** wherein the iterative optimizing of the geometric contour uses a level set framework.

15. (currently amended) The ~~method~~ processor as set forth in claim **13** wherein the iterative optimizing includes:

computing a new contour based on a current contour and a fuzzy membership classification of the pixels in the neighborhood of the current contour.

16. (currently amended) The ~~method~~ processor as set forth in claim **8** wherein the iterative eroding of the edges of the filled regions includes:

eroding using a process employing at least a first erosion pass in a first direction and a second erosion pass in a second direction.

17. (currently amended) The ~~method~~ processor as set forth in claim **8**, further comprising:

conditional upon the angiographic image being a black blood angiographic image, inverting the intensities of the image elements to generate an intensity-inverted image.

18. (original) A method for tracking a vascular system in an angiographic image, the method comprising:

identifying a plurality of vessel centers in three dimensions that are representative of the vascular system;

selecting a first vessel center;

finding a first vessel direction corresponding to the local direction of the vessel at the first vessel center;

defining a first slice that is orthogonal to the first vessel direction and includes the first vessel center;

estimating vessel boundaries in the first slice by iteratively propagating a closed geometric contour arranged about the first vessel center;

repeating the selecting, finding, defining, and estimating for the plurality of vessel centers; and

interpolating the estimated vessel boundaries to form a vascular tree.

19. (original) The method as set forth in claim **18**, wherein the estimating of a vessel boundary further includes constraining the iterative propagating by at least one of:

edges of a vascular structure image containing the first vessel center;

a neighboring vessel boundary; and

a pre-determined distance from the vessel center about which the geometric contour is arranged.

20. (original) The method as set forth in claim **18**, wherein the iterative propagating is computed at least in part using a fuzzy membership classification of pixels in a neighborhood of the contour.

21. (original) The method as set forth in claim **18**, wherein the finding of a first vessel direction includes:

constructing a Weingarten matrix;

obtaining a plurality of directions by implementing eigenvalue decomposition of the Weingarten matrix; and

selecting the first vessel direction from the plurality of directions.

22. (original) The method as set forth in claim **18**, wherein the identifying of a plurality of vessel centers includes locating a vessel center using one of a radial line method or a center likelihood measure method.

23. (original) The method as set forth in claim **18**, wherein the identifying of a plurality of vessel centers includes locating a vessel center using a recursive erosion method.

24. (original) The method as set forth in claim **23**, wherein the recursive erosion method includes:

flood-filling each vascular structure image in the slice; and

recursively eroding each flood-filled vascular structure image to identify at least one vessel center associated therewith.

25. (original) The method as set forth in claim **23**, wherein the recursive erosion method includes:

performing a first erosion pass in a first direction using a first moving window;

performing a second erosion pass in a second direction using a second moving window; and

repeating the first and second erosion passes a plurality of times until the remaining at least one region is identifiable as the at least one vessel center.

26. (original) An apparatus for characterizing a vascular system in a three-dimensional angiographic image comprised of voxels, the apparatus comprising:

a means for extracting from the angiographic image a two-dimensional slice formed of pixels;

a means for locating imaged vascular structures in the slice;

a means for flood-filling the imaged vascular structures to form filled regions defined by pixels having a first value;

a means for iteratively eroding the edges of the filled regions to identify vessel center points; and

a means for generating a plurality of vessel center points that are representative of the vascular system, the means for generating being in operative communication with the means for extracting, the means for locating, the means for flood-filling, and the means for eroding.

27. (original) The apparatus as set forth in claim **26**, further comprising:

a means for estimating vascular edges associated with the plurality of vessel center points; and

a means for combining the estimated vascular edges to form a vascular tree representation.

28. (original) An apparatus for tracking a vascular system in an angiographic image, the apparatus comprising:

a means for identifying a plurality of vessel centers in three dimensions that are representative of the vascular system;

a means for selecting a first vessel center;

a means for finding a first vessel direction corresponding to the local direction of the vessel at the first vessel center;

a means for defining a first slice that is orthogonal to the first vessel direction and includes the first vessel center;

a means for estimating vessel boundaries in the first slice by iteratively propagating a closed geometric contour arranged about the first vessel center;

a means for interpolating the estimated vessel boundaries to form a vascular tree after the selecting, finding, defining, and estimating have been repeated for the plurality of vessel centers.